

## CLAIMS

What is claimed is:

- 1 1. An optical modulator device comprising:
  - 2 a substrate formed from a semiconductor material;
  - 3 an optically active layer formed on an upper surface of the substrate, the optically
  - 4 active layer including a layer of SiGe having a quantum well to provide electro-absorption of
  - 5 light in the optically active layer;
  - 6 a layer of semiconductor material formed on an upper surface of the optically active
  - 7 layer; and
  - 8 an electrical contact formed on an upper surface of the layer of semiconductor
  - 9 material to provide an electric field to alter the electro-absorption of light in the optically
  - 10 active layer.
- 1 2. The device of claim 1, wherein the layer of SiGe comprises a layer of SiGe
- 2 nanocrystals.
- 1 3. The device of claim 1, wherein the layer of SiGe is a strained layer of SiGe having a
- 2 dopant to provide electrons in the strained layer of SiGe.
- 1 4. The device of claim 3, wherein the dopant is at least one of arsenic, phosphorus, and
- 2 antimony.
- 1 5. The device of claim 3, wherein the strained layer of SiGe is between 20 and 70
- 2 percent Germanium.
- 1 6. The device of claim 5, wherein the strained layer of SiGe is 27 percent Germanium.

1 7. The device of claim 3, wherein the substrate is formed from silicon.

1 8. The device of claim 3, further comprising:

2 a second layer of semiconductor material formed on an upper surface of the substrate;

3 and

4 wherein the optically active layer is formed on an upper surface of the second layer of  
5 semiconductor material.

1 9. The device of claim 8, wherein the second layer of semiconductor material is formed  
2 from silicon.

1 10. The device of claim 3, wherein the optically active layer further comprises:

2 a layer of semiconductor material formed on an upper surface of the first strained

3 layer of SiGe; and

4 a second strained layer of SiGe formed on an upper surface of the semiconductor  
5 layer to provide a second quantum well, wherein the second strained layer of SiGe is doped  
6 with arsenic.

1 11. The device of claim 10, wherein a ratio of silicon to germanium in the first strained  
2 layer is different than a ratio of silicon to germanium in the second strained layer.

1 12. The device of claim 1, wherein the optical modulator is an optical waveguide  
2 modulator.

1 13. The device of claim 12, further comprising an optical cavity in optical  
2 communication with the optically active layer.

1 14. The device of claim 1, wherein the layer of SiGe has a thickness between five and  
2 thirty nanometers.

1 15. The device of claim 1, wherein the substrate is formed from germanium.

1 16. An optical modulator device comprising:  
2 a substrate formed from a semiconductor material;  
3 a first reflective layer formed on an upper surface of the substrate to provide a first  
4 reflective surface;  
5 a first cladding layer formed on an upper surface of the first reflective layer;  
6 an optically active layer formed on an upper surface of the first cladding layer, the  
7 optically active layer including a strained layer of SiGe having a quantum well to provide  
8 electro-absorption of light in the optically active layer;  
9 a second cladding layer of dielectric material formed on an upper surface of the  
10 optically active layer; and  
11 a second reflective layer formed on an upper surface of the second cladding layer to  
12 provide a second reflective surface.

1 17. The optical modulator device of claim 16, wherein the strained layer of SiGe is doped  
2 with arsenic.

1 18. The optical modulator device of claim 17, wherein a concentration of arsenic in the  
2 strained layer of SiGe is greater than  $1 \times 10^{18}$  atoms per cubic centimeter.

1 19. The optical modulator device of claim 18, wherein a concentration of arsenic in the  
2 strained layer of SiGe is between  $1 \times 10^{18}$  atoms per cubic centimeter and  $6 \times 10^{20}$  atoms per  
3 cubic centimeter.

1 20. The optical modulator device of claim 16, wherein the strained layer of SiGe is  
2 between 20 and 70 percent Germanium.

1 21. The optical modulator device of claim 16, wherein the substrate is formed from  
2 silicon.

1 22. A method comprising:  
2 receiving an optical signal at an optical modulator device having an optically active  
3 layer, the optically active layer including a strained layer of SiGe having a quantum well to  
4 provide electro-absorption for the received optical signal;  
5 applying an electric field to the optical modulator device to alter the electro-  
6 absorption of the optically active layer;  
7 modulating the received optical signal responsive to the altered electro-absorption of  
8 the optically active layer; and  
9 providing the modulated optical signal to an integrated circuit chip.

1 23. The method of claim 22, wherein the strained layer of SiGe is doped with arsenic.

1 24. The method of claim 23, wherein the strained layer of SiGe is between 20 and 70  
2 percent Germanium.

1 25. A system comprising:  
2 a first integrated circuit (IC) chip formed from a silicon substrate, the first IC chip  
3 including an optical modulator with an optically active layer, the optically active layer  
4 including a strained layer of SiGe having a quantum well to provide electro-absorption of  
5 light;

6           an optical pathway optically coupled at a first optical pathway end to the optical  
7 modulator; and

8           a second IC chip having a photodetector optically coupled to a second optical  
9 pathway end.

1   26.   The system of claim 25, wherein the strained layer of SiGe is doped with arsenic.

1   27.   The system of claim 26, wherein a concentration of arsenic in the strained layer of  
2 SiGe is greater than  $1 \times 10^{18}$  atoms per cubic centimeter.

1   28.   The system of claim 27, wherein a concentration of arsenic in the strained layer of  
2 SiGe is between  $1 \times 10^{18}$  atoms per cubic centimeter and  $6 \times 10^{20}$  atoms per cubic centimeter.

1   29.   The system of claim 26, wherein the strained layer of SiGe is between 20 and 70  
2 percent Germanium.

1   30.   The system of claim 29, wherein the optically active layer further comprises:  
2           a second strained layer of SiGe formed on an upper surface of the first strained layer  
3 of SiGe to provide a second quantum well, wherein the second strained layer of SiGe is  
4 doped with arsenic.

1   31.   An integrated circuit comprising:  
2           a substrate formed from a semiconductor material;  
3           an optical modulator with an optically active layer formed on the semiconductor  
4 substrate, the optically active layer including a strained layer of SiGe having a quantum well  
5 to provide electro-absorption of light; and

6           an optical fiber having a first end in optical communication with the optical  
7   modulator.

1   32.    The system of claim 31, wherein the strained layer of SiGe is doped with at least one  
2   of arsenic, phosphorus, and antimony.

1   33.    The system of claim 32, further comprising a light-emitting source fabricated on the  
2   semiconductor substrate to provide an optical signal to the optical modulator.

1   34.    The system of claim 33, further comprising a photodetector in optical communication  
2   with a second end of the optical fiber to receive light.

1   35.    The system of claim 31, wherein the substrate is formed from silicon.

1   36.    The system of claim 35, wherein the strained layer of SiGe is between 20 and 70  
2   percent Germanium.